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COMMENT on Yuan *et al.*

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It has come to our attention that the work of Yuan et al.[1] is being represented as definitive regarding the existence of a particular nonstrange, isoscalar, spin three dibaryon, d^*, which we[2], among others[3, 4, 5, 6, 8], have proposed exists. We therefore wish to comment on this paper and its relation to ours and those of others.

In our work[2], the d^* dibaryon is constructed in terms of its constituent quark wavefunctions, which include significant distortion from those found in isolated baryons. It should be noted that these wavefunctions do not collapse into a simple, spherical system as proposed, for example, by Jaffe[9] for the H dibaryon. Our techniques have allowed us to demonstrate that this picture adequately reproduces known low energy baryon-baryon scattering amplitudes with only one or two fitting parameters.

At the other extreme are theories of baryon interactions without any quark substructure whatsoever. These also, in terms of effective potentials or meson exchanges, adequately reproduce known low energy baryon-baryon scattering amplitudes, albeit with a multitude of fitting parameters. Such approaches tend not to predict deeply bound dibaryons, with the exception of Ref.[6]. Rather, the states examined are generally found to have a character not very dissimilar from the deuteron, with small binding energies predicted[10], if any.

Approaches such as that of Yuan et al.[1] and similarly those of Thomas et al.[5] or Wilets et al.[7] take an intermediate view, including quark substructure of distinct baryons, but variously restricting interactions between quarks as due to exchanges of mesons or other collective fields, exchanges of gluons, or both. Some change of internal baryon structure is allowed in these models. Interestingly, the approaches that include or are restricted to only meson exchanges may be characterized as generally predicting dibaryon states with binding energies intermediate between the two approaches referred to above. They also can well describe low energy baryon-baryon scattering amplitudes or nuclei, albeit again with a significant number of parameters which must be fit to data.

We wish to suggest that the proper scientific response to this range of models and results is not to make a theoretical judgment about which is more likely to be correct. Rather we feel that it behooves us all to acknowledge that our understanding is limited and to recognize two issues: One is the question of the range of scales over which nucleons and mesons may be viewed as having rigid internal structures uninfluenced by their surroundings. The second is the question of whether or not quark propagation, at least at low energies, can be coherent over ranges larger than about one fermi, or conversely, whether their propagation must always be re-expressed in terms of composite, colorless, degrees of freedom.

Yuan et al. also criticize the manner in which we use a nonrelativistic form of the confinement potential. However, as we have explained in Ref.[11], our nonrelativistic model Hamiltonian is an extended, effective matrix element approach rather than simply a potential model. It is sufficient to define a quantum mechanical model if all of the matrix elements of the Hamiltonian in the model Hilbert space have been fixed. Their concern regarding the nonorthogonality of the left and right centered orbits in our approach is misplaced since the fixing of the matrix elements by our model assumption is clearly defined. As has been emphasized before, our understanding of confinement is limited so it is perhaps unwise to narrowly restrict model approaches to any description of confinement.

Our view is that it is indeed fortunate that this range of models with differing physics assumptions produces a range of predicted masses for the d^*. This allows the experimental search for such a state, and the mass determination if it is observed, to distinguish among pictures which a priori have similar strengths for their claims of accuracy. This makes experiments, such as the proton induced excitation discussed by Wong[8] and possible experiments involving electron scattering[12], extremely important to carry out. Whatever the result of these experiments, they will have much to say about how we should view the realm of low energy strong interactions in terms of quarks.

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References

[1] X.Q. Yuan, Z.Y. Zhang, Y.W. Yu, and P.N. Shen, *Phys. Rev. C***60** (1999) 045203 or nucl-th/9901069.

[2] T. Goldman, K. Maltman, G.J. Stephenson, Jr., K.E. Schmidt and Fan Wang, *Phys. Rev. Lett.* **59** (1987) 627; *Phys. Rev. C***39** (1989) 1889; Fan Wang, Guang-han Wu, Li-jian Teng and T. Goldman, *Phys. Rev. Lett.* **69** (1992) 2901 or nucl-th/9210002; Fan Wang, Jia-lun Ping, Guang-han Wu, Li-jian Teng and T. Goldman, *Phys. Rev. C***51** (1995) 3411 or nucl-th/9512014; T. Goldman, K. Maltman, G.J. Stephenson, Jr., Jia-lun Ping and Fan Wang, *Mod. Phys. Lett. A***13** (1998) 59 or nucl-th/9803002.

[3] A.Th.M. Aerts, P.J.G. Mulders and J.J. deSwart, *Phys. Rev. D***17** (1978) 260.

[4] K. Yazaki, *Prog. Theor. Phys. Suppl.* **91** (1987) 146.

[5] P.J.G. Mulders and A.W. Thomas, *J. Phys. G***9** (1983) 1159; K. Saito, *Prog. Theor. Phys.* **72** (1984) 674.

[6] T.Kamae and T.Fujita, *Phys. Rev. Lett.* **38** (1977) 471.

[7] S. Pepin, Fl. Stancu, W. Koepf and L. Wilets, *Phys. Rev. C***53** (1996) 1368.

[8] C.W. Wong, *Phys. Rev. C***57** (1998) 1962.

[9] R.L. Jaffe, *Phys. Rev. Lett.* **38** (1977) 195; 617(E).

[10] J.A. Niskanen, private communication.

[11] J. Ping, F. Wang and T. Goldman, *Nucl. Phys. A***657** (1999) 95 or nucl-th/9812068.

[12] Di Qing, He-ming Sun, and Fan Wang, nucl-th/9912069, submitted to *Phys. Rev. C.*